ART. V.—CONTRIBUTIONS TO ENCEPHALIC ANATOMY.

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PART III.

The relation existing between the external shape, and the internal structure of certain parts of the Encephalon.

THE great law announced by Meynert, that the diameter of a fasciculus depends upon the mass of grey matter with which it is connected, is susceptible of some modification. The nearer we approach the highest centres, and the higher we pass up in the animal scale, the less exactly does this statement apply. I have compared the *pes pedŭnculi* of a human brain, whose cortex was almost as richly convoluted as that of Gauss, the astronomer's brain, with the *pes pedunculi* of an epileptic dement, whose convolutions were of the simplest type, and although I found a difference in favor of the former, yet this difference was by no means proportionate to the great preponderance of cortical grey matter.

On the other hand, with the increasing development of the cortex, the aggregate mass of projecting, associating and commissural fibres, constituting the *centrum semi-ovale*, grows more rapidly than the cortex itself. A richly convoluted brain has relatively more white substance than a poorly convoluted one, and every transverse section of the encephali of lower animals proves this; the higher we ascend the thinner becomes the relative thickness of the grey substance as compared with the white lamina entering it. We must of course consider the fact that, at the same time, the absolute thickness of the cortex increases, and not only this, but it also becomes far richer in cellular elements. I am able to fully confirm Meynert's statements that of the several layers constituting the cortex, that one which underlies the pia, designated by him as the *ependyma* formation, and which represents the most barren part of the grey matter as far as the cells are concerned, is thickest in the lowest animals. I find this ependyma formation to

measure from three-fourths to four-fifths of the entire cortical thickness, in the snapping turtle. In the common bat, it amounts to one-fourth on the convexity of the hemisphere; in the cat to one-eighth, and in the human brain it varies from one-twelfth to one-sixteenth.* While these figures confirm the proportionate progress of the cortical richness as to cells, they differ absolutely from those given by Meynert, who assigns:

1.	For the human being, - - - -	$\frac{1}{8}$ — $\frac{1}{10}$
2.	" " capuchin ape, - - - - -	$\frac{1}{6}$ — $\frac{1}{7}$
3.	" " dog, - - - - - - -	$\frac{1}{6}$
4.	" " cat, - - - - - -	$\frac{1}{5}$
5.	" " bat, - - - - - - -	$\frac{1}{4}$
6.	" " calf and deer, - - - - -	$\frac{1}{3}$

of the entire cortical thickness, to its outermost layer.

Although this fact, conjoined with several others, would tend to prove that the ganglionic cells of the cortex are its noblest, and most differentiated elements, and are intrinsically connected with conscious sensation, thought and action, yet I must confess that I have recently found reason for considering Henle's supposition that even the so-called neuroglia is of a nervous nature, as a not improbable one. A remarkable discovery made by a recent writer in the *Archiv fuer Wissenschaftliche Zoologie*, seems to confirm this view. He found that the symmetrical, globular and convoluted masses which lie in front of the cephalic ganglia, in intimate connection with them, and which represent the cerebrum of the vertebrata, in the bee, ant, and other hymenoptera, consist of two optically different substances, the outer being *grey*, the inner *white; neither this grey nor this white substance show any cells or fibres*, they are both composed of a fine molecular substance.

The functions of such molecular substance (chemically and optically almost identical with the protoplasm of the nerve cells), are probably similar to those of the latter, although doubtless

* In a macrocephalic idiot whose brain *weighed* 68 *ounces*, and which was fairly convoluted, the thickness of the ependyma layer was one-seventh of an inch.

far more rudimentary. The palpable lesions of insanity are often limited to this tissue!

Thus much for the present, regarding the general relations of the grey and white substance of the hemispheres, let us glance for a moment at the development of the convolutions. Aside from the well known fact that, *cæteris paribus*, large animals have a more richly convoluted brain than small animals, aside from the fact that the arrangement of the convolutions depends on the proportion which the diameters of the cranium bear to each other, and the influences which are exercised during embryonic development, we must accord some prominence to the influence of hereditary transmission, exercised in a manner independent of the mechanical surroundings. We find for example, crania among the pachydermata which are similar in their diameters to the crania of certain carnivora and rodentia, yet the convolutional arrangement, aside from a general resemblance in the parallelism and direction of the folds, is on an entirely different plan in all three of these groups. The extremely dolichocephalic fox resembles more closely the most brachycephalic of the cat tribe, than it does that of any herbivore, no matter how similar in its cranial diameters. If we examine such casts of crania of extinct species of animals as have been found by palæontologists* in the tertiary strata, notably of the marsupials and carnivora figured by Gervais, we find everywhere the same great family type expressed in all. It is suggestive in this connection that a living marsupial, one which strongly suggests the extinct branch from which the placental carnivora have been derived, possesses a strikingly carnivorous brain, as regards the convolutions (Thylacinus).

It is not a correct inference to suppose that special convolutions signify a greater development of special functional areas. The arrangement of the medullary strands on whose abutment and peripheral termination the function of any cor-

* Some valuable information regarding the morphology of the convolutions may be expected from fossil crania, and American beds may contain many valuable specimens of this kind. I am informed that Princeton College possesses the supposed intracranial cast of a Dinoceras (Marsh).

tical territory depends, is too inconstant to admit of this; we shall find that such medullary strands may terminate in different cortical areas in different animals, and our logical deduction must be that, the simpler functions may be situated differently accordingly. Even the great fissures, such as the central, the intraparietal, the calcarine, the transverse occipital (of apes), do not always separate differently connected areas, for a bundle frequently divides at the base of such deep fissures, and gives off fibres to both the cortical areas separated by these fissures. With regard to the less important secondary gyri, their course and number, dependent on the combined influence of all the influences above referred to, is often varied by what might be termed *fortuitous* circumstances, namely, the position of vessels. While contrary to Reichert's views, it is now generally conceded that those sulci which characterize any given brain, are altogether independent of the position of vascular twigs, it seems to me that the less constant secondary and tertiary gyri are not always free from such an influence. I have frequently found that every transition exists between the simple groove in which the medium-sized vessels cross a large gyrus, and the shallow sulci which separate the latter into secondary folds. It could be urged against this that the vessel might have *secondarily* selected a pre-existing channel, but it is well known that in man at least, the tertiary and many of the secondary gyri, are formed after birth, when all the larger vascular twigs are already developed.

That the primary sulci which characterize a given brain are independent of such influence, can be readily seen in the case of the pteropus, an animal whose brain has not yet received due attention, and which it is my purpose to describe ere long. Here there are several rudimentary sulci which run parallel to the median fissure, while the arteries in their vicinity run a transverse course, and cross these fissures in a vertical direction. Here obviously, sulci and vessels are developed independently of each other, and where at the point of crossing of a vessel and a sulcus, one influences the course of the other, it is the former which is diverted from its direction, not the latter.

Altogether the convolutions of the cerebral convexity are

dependent on the mathematical principles enunciated by Wundt. These principles are to be modified in the case of the S-shaped convolution, or the cornu ammonis. The cornu ammonis is the first convolution proper formed in the lower mammalia. It is relatively larger in the Vespertilionidæ, and Muridæ than in other animals which I have examined in this direction. I believe that I have found its first trace in the turtles. It seems that in the latter class of reptiles, the free internal edge of the hemispheric vesicle is turned inwards, towards the ventricular cavity. It is on this part of the edge that a structure similar to that of the bat's cornu ammonis is found.

This condition is found at one period of embryonic existence in the mammalia. It is easy to understand that, when a body endowed with the elastic tension of organic substances has received a curved direction, it will, unless external circumstances interfere, continue its growth in that direction. It is this principle which produces a spiral cochlea from a simple horn-shaped sac. Spiral also would be the cornu ammonis, if it did not meet with resistance to further spiral extension before completing the first turn; that resistance is furnished by the meanwhile hypertrophied hemispheric wall, and the second part of the S is produced by a curved growth in the opposite direction. After the cornu ammonis has reached its perfection in the lower mammalia, it loses in relative importance in the higher, and I have remarked is proportionately less voluminous in the herbivora than even in man. The coincidence may be without any deeper significance, but it is certainly striking, that the more rapid the natural motions of a mammal, the larger relatively is its cornu ammonis; the bat and mouse are remarkable for the size of this convolution, and it diminishes gradually as we pass from the rabbit, to the dog, monkey, man, and larger herbivora.

Not only does the size of a fasciculus depend on the mass of the grey matter with which it is connected, but it also influences the size of other grey masses with which it establishes associations; the well known dependence of the lateral lobes of the cerebellum upon the opposite cerebral hemisphere is a well known instance. In the dog, we have moderately devel-

oped cerebral hemispheres, and consequently small cerebellar hemispheres, the vermis being proportionately large. In the Cynocephalus the hemispheres of the cerebellum are already sufficiently developed to conceal the *flocculus* from view, but the vermis is still fairly developed. In the anthropoid apes, as the chimpanzee, and in man, the hemispheres flare out with a globular border, and the vermis is rudimentary.

While these changes, dependent on the progressive increase in the size of the hemispheric dimensions, have taken place, the commissural tracts have undergone a like change. There is a wide chasm between the medulla and pons of the rabbit and those of man, yet this chasm is completely bridged over. In the rabbit, the crura cerebri are small, and the pons, which is derived from them, is likewise rudimentary; on both sides of the point where the anterior pyramids emerge, there is a band ot transverse fibres known as the trapezium (Dean), which is about as deep as the pons itself. In the dog, the pons already preponderates over this trapezium, in the baboon, but a small edge of the latter is visible, *in the chimpanzee* and the human being it is completely hidden from view.

With the increase of the pes pedunculi and the parallel increase of the pons proper, and progressive concealment of the trapezium, the anterior pyramids gain in bulk; as they gain in bulk, they become more columnar in character, and a body which has hitherto lain behind them is pushed to the outer side. This is the explanation for the presence of a distinct olivary protuberance in man, and of its absence in the lower mammalia. It is not the olivary body which is wanting in the latter, but that position which would cause its protrusion is not given it. Another element which enters into this question of the prominence of the olive, is the development of the dentated nucleus of the olive itself; a simple lamina in the lower mammals, a rudely folded line in the dog, it increases to the richly crenulated nucleus of the human olive,* and consequently gives to the olivary prominence more bulk.

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* I am not prepared to confirm the statement of a recent French writer, that the olivary body of the dog corresponds only to the internal accessory olive of man.

The reason for this richer development of the olive in the highest mammals lies in its dependence on the cerebellar hemispheres, a dependence already hinted at in Part II., as due to its connection with the restiform decussation.

We thus perceive that anatomical peculiarities, apparently of the most independent and disconnected character, are, in reality, but an expression of one great harmony, and that the shape, volume, and relations of the basicerebral parts are but the expression of the ratio of prosencephalic preponderance. This preponderance increases to such a degree in the anthropoid apes and man, that the cerebral hemispheres may well be likened to a great empire, on whose strength depends the proper subjection and prosperity of tributary states; a parallelism carried out in the case of unilateral atrophy of the cerebral hemisphere, where the opposite hemisphere of the cerebellum, olivary nucleus, brachium conjunctivum and anterior pyramids equally undergo diminution in volume, or, in the case of the imbecile or terminal dement in whom the rhythmical motions of lower animals once more become manifest.

In all the *amniote* vertebrates, the anterior inflection of the embryonic axis is the factor which determines the possible predominance of the prosencephalon. I say possible, because this preponderance is not always actual, especially in the case of reptiles, and to a lesser degree in birds. One *mechanical* reason is, that in the embryonic reptile and bird, the primordial ocular vesicle early attains such dimensions that the parallel developed mesencephalon must also predominate in growth, and this prevents the backward extension of the hemispheres, on which their ultimate increase depends. That another, not *purely* mechanical factor is here active, and that this is after all the most important one, is shown in the great difference which later obtains between the reptile and bird. In the former, the hemispheres possessing but a slight impetus to growth, remain stationary as soon as an extension backwards is prohibited by collision with the mesencephalon; in the bird, however, the hemispheres overcome this obstacle, and since it is impossible to crowd the corpora bigemina backwards, they separate them and push them downwards and laterally. This

explains the apparently anomalous position of the corpora bigemina in birds, a position which is carried to its furthest extreme in the parrot.

In examining into the question of the prejudicial influence of the early mesencephalic preponderance on cerebral growth, and referring the former to the coincident great size of the eye, we find that the latter element exercises another influence in the way of cerebral retardation, and that of a direct mechanical nature. If we examine the whole range of the amniota, we shall find, as a rule, that the larger the eye, and consequently the orbit, the narrower and more hollowed out is the anterior portion of the hemisphere. The rabbit has a narrower frontal lobe than the rat, the badger than the mole, the dog than the bear, the barn fowl than the parrot, and the aves, as a whole, than the mammalia.

In tracing cerebral morphology to certain facts of embryology, and to the influence of peripheral on central development, or, of external mechanical factors, we should not forget that while these influences can be legitimately considered to affect cerebral development, they are by no means primary causes. The dimensions of the cerebrum of a reptile are the result of the operation of the same great hereditary influence which determines the inflection of the basicranial axis, and the relatively early and preponderating growth of the eyeball. The various elements which *seem* to determine the special shape of a given brain, are but an expression of the mutual harmony existing between physiologically related organs. Where the ancestry has acquired a cerebral development beyond that which an allied animal group possesses, this development leaves a sufficiently powerful impress on the medullary trace of the descendant, to enable it at the expense of typical homology, to overcome prejudicial external influences, as in the case of the bird's brain just cited.

In comparing the various classes of vertebrate animals with each other, we find that each class has separate characteristics of its own, and that the earlier a special class has separated from the common vertebrate trunk in geological history, the more aberrant is its cerebral structure from that type which is considered the type characteristic of the vertebrate brain.

The bony fishes (Teliosts) which have become a separate group as early as the later Silurian age, for example, have lost the lateral ventricles entirely, their cerebral lobes are solid. In this fact I can find no reason for going so far as Wilder, who asserts the cerebral lobes of the teliost to be non-homologous with those of other vertebrates; he seems to have overlooked the fact, that originally the whole nervous system of such embryos, as in the case of the embryonic salmon and Gasterostens, is apparently solid. It illustrates rather what changes may be effected in any organ through the lapse of time by, as yet, unknown agents.

The birds furnish another illustration. This class, according to the unanimous testimony of European and American explorers, constitutes the terminal developmental stage of a group of saurian reptiles which separated from the common reptilian stock at about the Triassic period. In all the immense lapse of time intervening between then and now, the optic lobes have become crowded to an anomalous position, and other changes have occurred to be yet considered.

The time will undoubtedly come, when we shall be able to construct the ontogeny and phyllogeny of the brain.

In drawing our inferences from cerebral structure, as to its function, we shall therefore have to consider not one, but innumerable collateral questions. The shape, volume and relations of the encephalon depend, first, upon the type of brain peculiar to the class of animals to which a given species belongs; second, to the aberrant influences which may have become gradually potentialized in the direct ancestry; thirdly, to mechanical influences, exercised upon the brain, and in accordance with ontogenetic harmony; fourthly, to physiological atrophies or hypertrophies of special peripheries; fifthly, to the influence exercised by various centres on each other; lastly, to individual variations. Many errors committed in the past, have been due to the fact that only one of these elements has been considered at a time. Thus the great embryologist, His, has been led to refer everything to the influences exercised by the curves of the embryonic axis, and the foldings of certain surfaces. The reformer of modern cerebral anatomy, Meynert, has, as we have mentioned, overlooked class distinctions in

referring the relative size of special strands or centres to corresponding developments of the periphery, and it is needless to refer to the numerous errors committed in regard to the convolutions, not only by those guilty of the notorious *lapsus* of phrenology, but also by recent morphologists.

We shall in the sequel, having closed these preliminary remarks, proceed to study the encephali of certain species of animals noted either for their peculiar zoological position, or for the development of special peripheries.

PART IV.—THE BRAIN OF THE MENOBRANCHUS.

Around the central canal of the cord in this amphibian we find from fifteen to thirty large, oblong bodies, which are closely crowded together. Even in deeply stained specimens one is very apt to overlook a delicate protoplasm surrounding them, and thus to consider as *cell equivalents* what are in reality merely the gigantic *nuclei* of *epithelial cells*. Where these cells flare apart at their base, other bodies, similar in size and appearance to the nuclei referred to, but without any demonstrable protoplasm, are intercalated with one extremity. Succeeding them, similar but more loosely aggregated bodies are disposed without any special order, and, with certain modifications, to be described, these extend to the apices of the grey cornua.

There are a few cells at the extremity of the anterior cornu which, from the anatomical relations of their processes to the nerve roots, are to be considered as genuine nerve cells; an occasional such cell is also found in the most posterior portion of the trigonum cervicale, or at the bases of the anterior and posterior fissures. Starting with these cells and passing to the central epithelium, we shall find every possible gradation between multipolar nerve cells and epithelial cells!

In order to understand this remarkable transition clearly, let us first study the two extremes of the transition series:

I. The nerve cell of the menobranchus consists of a large, finely granular central mass, nearly as large as, and in some instances even larger than, the immense red blood corpuscles of this species. This mass stains deeply in carmine, and

occasionally has the appearance of containing a more or less distinctly marked central body. Around it there is a thin, delicate shell of protoplasm, which is continuous with the axis cylinder and protoplasmic processes. Like the latter it does not stain very deeply in carmine or hæmatoxylin.

Although the central body preponderates so immensely over the outer substance, it must be considered as its nucleus, and this for the following reasons: 1st. The nerve cell processes never can be traced to have any connection with the former, but, on the contrary, their fibrillæ, when their course is clearly visible, can be always traced over or by its side, through the outer substance, to some other process, in a manner similar to that claimed by Beale for the nerve cells of the mammalia. 2d. It stains more readily and deeply in carmine. 3d. It is more granular than the substance which I designate as the protoplasm. 4th. Although sometimes drawn out to an angular shape, at a point where a nerve cell gradually becomes attenuated to a spindle form, it never extends into the processes proper.

II. The ependymal epithelial cell consists of a delicate, apparently hyaline protoplasm, which is thickest at that end of the cell which faces the central canal or the ventricular lumen, and thence gradually thins down until no longer visible at the root of the cell. The main mass of the latter is made up by the oblong nucleus already referred to, which stains to the same degree, and has the same optical appearances and dimensions as the nucleus of the nerve cell of the same animal; it differs from it in the sole respect that it is more oblong; but even here there are exceptions, while a few of the epithelia have spherical or ellipsoidal nuclei, some of the nerve cells have oblong ones.

As already stated, the series of bodies immediately underneath the ependymal epithelium no longer possess a demonstrable protoplasm. They resemble, in every respect, the epithelial nuclei, and are to be considered as *free nuclei*. The further outwards we pass the more spheroidal they become, and now they begin to assume peculiar relations to the delicate fibrillæ which run in their vicinity. While the mere enclosure of one of these free nuclei by a bundle of nerve fibrils might

be considered accidental *per se*, yet when we find that these nuclei are by preference in relation with those groups of fibrillæ which undergo a methodical concentration into axis cylinder and other processes, and when we find that those nuclei have become the rendezvous of such strands running in all the directions, and subdividing in all the manners of a typical multipolar nerve cell, and finally, when we perceive a delicate protoplasmic mold cast into the fibrillar network which encages the free nucleus, we will perceive a process by which the latter becomes elaborated into a nerve cell nucleus.

During this process it undergoes no visible histological metamorphosis whatever. Some of the compound bodies which arise from the condensation of fibrils around the nuclei, and which I consider the physiological if not the anatomical homologues of nerve cells, possess no protoplasm whatever; others show it but indistinctly; but, aside from this, they appear entirely identical with the cells described as nerve cells.

This transition can be much more finely seen in the medulla oblongata than in the spinal cord,—the nerve cells are larger, their processes more numerous, and the layer of subependymal cells is thicker. Although there are no nuclei for the cranial nerves, in the proper sense of the term, yet at the origins of the auditory and trigemini nerves this layer of cells and nuclei is drawn out to a peninsular formation, and here the finest transition forms can be observed. The raphe particularly furnishes fine examples, and I have several specimens of what appear to be cells with two axis cylinder processes, the one entering the other crossing the raphe.

The existence of demonstrable connecting links between epithelial and nerve cells, occurring as it does in the nervous system of an animal which represents a *larval type*, is exceedingly suggestive from an embryological point of view. Hensen* has conclusively traced the development of the nerve cells of the anterior cornu from the proliferating epithelium of the primitive medullary canal, and it appears that in the

*Hensen, "Beiträge zur Entwicklungsgeschichte des Kaninchens und Meerschweinchens;" *Zeitschrift fuer Anat. und Entwicklungsgeschichte*, II., 1875.

menobranchus we have an instance where this ontogenetic relation has remained permanent in a double sense,—first, as regards the undeveloped condition of the nerve cells themselves; secondly, as regards the permanent topographical union of these nerve cells with their mother bed, viz.: the free nuclei and epithelium.

The peculiar manner in which an, as it were fortuitous congregation of fibrils around a free nucleus, results in a compound formation approaching the full nerve cell *gradation* in structure, receives much light from the researches of Schmidt (New Orleans). It adds another to the numerous evidences which are accumulating in favor of the view, that in many, at least of the multipolar nerve cells, the nerve fibrils do not terminate in the nerve cell, but pass through it, so that the protoplasm constitutes merely a cement of the mass. This alters nothing, necessarily, of the physiological views entertained regarding nerve cells, but whether these are to be considered as cellular units in the traditional sense of the term, is a question.

While the medulla spinalis and oblongata contain a fair proportion of unquestionable nerve bodies, and these exhibit quite complex relations to nerve roots and other fasciculi, the higher centres show a much more rudimentary condition. Multipolar nerve cells do not occur here, and no subependymal white nerve substance is developed.

That the lobi optici should exhibit a rudimentary structure is not to be marveled at, since the sensory periphery which is projected in these lobes is itself rudimentary. (The eyes of the menobranchus are rudimentary and concealed under the epidermis.) It and the hemispheres have as a common character, a low epithelium on the ventricular aspect, which is followed by a dense layer of free nuclei, becoming more and more scattered the nearer we approach the surface. This whole thickness of the hemisphere is to be considered cortical substance, and the outer molecular layer, which presents the same appearance as the basis substance of the human cortex, corresponds to the first layer of Meynert. With this, the fact that, where medullary strands enter the cortex from the rudimentary thalamic region, they frequently send bundles or single fibres into this

outer layer, is in no contradiction. Even in the case of the highest animals, certain convolutions of the medial aspect of the hemispheres, which are of a lower structural type, have their white substance on the outside, and the lower mammals exhibit distinct fasciculi originating in this substance or passing through it (rat. rodentia). Among the round free nuclear bodies this neuroglia shows a fibrillary structure, and the closer we approach the ventricular floor, the more distinct this appearance becomes. Where an epithelial cell has been torn loose* by the section knife and isolated from its fellows, it is often possible to see such fibrils entering its basal protoplasm, and this is not infrequently observed to occur with individual attenuated free nuclei nearer the surface. In no case have I seen any indubitable evidence that such fibrils joined the substance of the free nuclei in thin sections. I can always detect a delicate protoplasm around the free nucleus, or where this is absent, trace the fibrils around and past the nucleus to their concentration point at the other extremity of the cell. At that extremity of these rudimentary ganglionic nuclei which is directed to the periphery of the hemisphere, they are drawn out to a point and thus assume a pyramidal appearance; it is possible, therefore, that they with the adjoining fibres may present the homologue of a tri- or multipolar pyramid, but I have discovered no distinct appearances of that kind either in the hemispheres or the optic lobes. In the relatively large olfactory lobes, such bodies are found, and altogether the structure here is better differentiated than in the hemispheres. Many of the cells are forced into parallelism with the convoluted nerve fibres, and together with them constitute *glomeruli olfactorii* such as have been described in higher animals. Here the nerve cells can also be traced from a central epithelium surrounding the ventricular cavity of this lobe.

The nerve fibres of the reticular formation in the medulla oblongata appear to anastomose by transverse and radiatory radicles, but as these very fibres run a wavy course, this appearance may be a delusion.

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*The aggregation of the free nuclei beneath the epithelia is very loose, and the latter, as well as the former, are easily separated in thin sections.

In closing the description of the histological peculiarities of the menobranchus, and before proceeding to describe the morphology of its encephalon, I would refer to a peculiar kind of globules found on the ventricular parietes. These are round globules, or amorphous aggregations of an opalescent greenish material, which, with or without a surrounding granular detritus cover the ependyma; the individual globules are as large as a human red blood corpuscle, and larger, up to twice these dimensions. I found one such body in the centre of the nucleus of an epithelial cell. As to their nature, whether they constitute a secretion, an exudation, or an artefact, I am unable to state anything. I have not verified their occurrence in the fresh specimen, but found them in specimens hardened in bichromate of potash and chromic acid combined, and equally in specimens which had not been touched by alcohol as in those in whose preparation that reagent had been employed.

The central nervous system of the *siren** exhibits the same histological peculiarities as that of the menobranchus, and we may assume that all the amphibia possessing permanent *branchia* possess the same. It would be very interesting in this connection to study the brain and cord of the *polypterus*. While the bony fish constitute an independent offshoot from the typical plan of cerebral development of the vertebrata, and the plagiostomi present us with other, but different typical modifications, the urodelous amphibia represent a nervous system of great simplicity it is true, but constructed on an identical plan with that of the sauropsida and mammalia. The study of such a primitive and larval nervous system consequently forms a convenient starting-point for a comprehension of the higher forms. As I shall show it will lead to a considerable modification of the projection theory.

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* For two specimens of the siren and seven menobranchi I am indebted to the kindness of Charles Dorner, Ph. D., Superintendent of the N. Y. Aquarium.